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ABSTRACT

At Tacoma Community College (Washington) a chemistry course was taught using instructional objectives. This document describes the course in terms of writing the objectives, instructional procedures and student attitudes. The instructor's overall conclusions were: (1) student reaction to the use of instructional objectives was very favorable; (2) the instructor's role in the classroom had changed from that of lecturer to discussion leader; (3) a very large amount of course preparation time was required for the written materials; and (4) classroom discussions were lively. Data regarding student performance indicated that what was learned using objectives and repeat testing was about equivalent to that learned with the conventional lecture-discussion method. Most of the students felt that it was easier and more efficient to learn using objectives. (RN)

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# MANAGING CHEMISTRY INSTRUCTION BY OBJECTIVES -- A CASE HISTORY

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MANAGING CHEMISTRY INSTRUCTION BY OBJECTIVES -- A CASE HISTORY

## INTRODUCTION

In the summer and fall of 1971, the Washington State Office for Community College Education sponsored training sessions in organization and management theory for small groups of community college personnel. A consultant, Marshall van Ostrom, planned and directed the sessions.

After ten such training sessions, I tried to put organization theory into practice in an introductory chemistry class which I had taught previously and was about to teach again during the next two quarters. In the jargon of our training sessions, I proceeded to "manage my students' learning experiences by using instructional objectives." This is an account of my efforts and of the excellent student responses to them.

## WRITING OBJECTIVE STATEMENTS

Central to van Ostrom's plan for managing instruction is the writing of explicit instructional objectives according to a highly stylized format. An example written for the introductory chemistry student is as follows:

> To increase the number of element symbols which can be written from memory, from 0 to 20, by October 10, 1972, using a test period of 6 to 4 minutes. (The test conditions must also be specified precisely, but they are simply referred to here.)

There are several key parts to this very formal objective format, which should be pointed out.

Every objective, according to van Ostrom, must begin with "To learn," "To establish," "To increase," "To write," or some other infinitive form. The 0 to 20 value in the objective statement above signifies the student's beginning and required final skill levels. (When the initial level is zero, it is some-

times omitted from the written objective as is the case in Appendix A.) In addition, a target date for completing the objective is always included, and finally, the conditions under which the objective is to be reached (6 to 4 minutes of test time) is always shown for accounting and evaluation purposes. In the van Ostrom system, the higher cost is stated first to indicate the maximum acceptable value. For the example cited, achieving the result in more than 6 minutes would represent a "problem" situation to be corrected, while achieving the objective in less than 6 minutes, but in more than 4 minutes would represent "success." Use of less than 4 minutes would represent "excellence."

These objective statements thus define the instructional goal as carefully as possible and specify the success level in such a way that an accounting can be made. In the work reported here, however, I was ultimately led to the use of much simpler objective statements (Appendix B).

## SIMPLIFIED OBJECTIVE STATEMENTS

My two criticisms of the van Ostrom objectives are that they tend toward awkwardness, and that the inclusion of a cost analysis factor (i.e., 6 to 4 minutes of test time) is of little practical value. On the first point, I will simply say that the most useful objectives will be those that can be read and understood by a very wide variety of students. Less able students will have difficulty with the complexity inherent in the van Ostrom system. On the second point, I believe that there is little value to be gained in keeping track of the length of time it takes to teach or learn a particular study unit or to answer a test question. Teachers and students generally do it only in gross terms. Three days of class time may be scheduled for discussion of the periodic chart or the structure of atoms, for instance, but within that period good teaching requires that there be no minute-by-minute schedule. A good instructor will monitor class responses and thus determine its ability to progress. A mistake in

presentation, more than average discussion, a distraction, or an unexpected opportunity for teaching and learning -- any of these can and usually do disrupt the classroom schedule. As a result, there is little incentive to establish a system for step-by-step auditing of classroom time, no matter how appealing the idea may be. The cost in instructor time for such activity could be expected to be very high and the benefits quite low.

## INSTRUCTIONAL PROCEDURES

To carry out my trial program, I first identified 10 major instructional units which appeared to be appropriate for a beginning chemistry course (Appendix C), and later I wrote highly detailed objective statements for each one. Writing the objectives was facilitated greatly by first writing a list of typical test questions for each instructional unit, followed by tailoring objective statements to each type of test question. I want to stress this point heavily because so many instructors seem to have trouble writing a comprehensive list of objective statements. In my experience, writing typical test questions first simplified the writing and compiling of objectives enormously.

While writing objectives represented an early and key step in the management of my instructional situation by objectives, I quickly decided that far more work was going to be necessary, and that a number of other changes in conventional instructional practices should also be incorporated into my plan. I believe that specifying objectives and mechanically evaluating performances are only a small part of the instruction-learning activity. Translations, explanations, practice and corrective evaluations are also important parts. I believe the student is being shortchanged if he is simply handed a list of learning objectives and a final examination. If teachers redefine their roles to involve only those essentials, they will soon find themselves replaced and students will be the worse off for it. As a result, I took the following additional steps in preparing my course:

1. Detailed explanations and problem exercises for the most difficult study topics were written and mimeographed.

2. About 20 general chemistry texts from the library's collection were placed on the reserve shelves.
3. Three equivalent tests for each study unit were prepared.
4. Explicit performance criteria were written for the A, B, C, D and W grades (no E's were programmed into the course).
5. A general instructional memo for the incoming students was prepared which stated: (a) that they could use any or all of the reserve texts in the library instead of purchasing the conventional course textbook; (b) that students would be tested on the current study unit at least 3 times per week so that each one might detect his learning progress and receive help where needed (students would continue to take equivalent tests until they demonstrated mastery of each unit by passing at least one unit test with a score of 80); (c) that there were definite, well-defined performance requirements for each letter grade to be awarded in the course (A, B, C, D and W); (d) that there was a course requirement for each student to read two non-textbooks in chemistry or physics during the quarter and to write a two-page report on each; and (e) that a student could withdraw from the course with a W grade at any time during the quarter. (See Appendix D.)

Put together with the objectives, these arrangements seemed to me to provide all of those course characteristics which I either believed in or else thought were worth trying.

## REVISED INSTRUCTIONAL PROCEDURES

Prior to the second quarter of this work, as a result of student suggestions and my own observations, all of the instructional objectives were rewritten in a simplified form. (Appendix B.) The laboratory experiments were also rewritten

(due mainly to student criticism). In addition, the grade requirements were made somewhat more stringent for the second trial at teaching Chemistry 100 by objectives.

## COMPARISONS

Since I also had taught this course a year earlier, I finished the two quarters with 3 classes to compare with one another -- the first taught in the normal discussion-lecture style, the second using objectives of the van Ostrom type, and the third being an "improved version" of the second quarter's work. My overall conclusions were:

1. Student reaction to the use of instructional objectives was overwhelmingly favorable. Many students commentad that they appreciated knowing what was expected of them and that the instructor was trying to help them succeed.
2. The use of objectives did not eliminate my role in the classroom, but it was changed. I gave far fewer "canned lectures." Instead, I answered questions and was able to use my experience to form the basis of spontaneous comments. This change seemed to please everyone.
3. The original style of writing objectives (van Ostrom's) was not as satisfactory as was the later modification (Appendix B).
4. The amount of secretarial time required to prepare the original handout material (explanations, experiments, and tests) was greater than that normally available to the classroom instructor.
5. As noted above, the amount of course preparation time required for the written materials was very large for the first trial, but it was less for the second, and for additional classes in the future, probably would be very little. The amount of instructor preparation time for each individual class presentation was relatively small once the objectives and supplementary materials had been developed.

6. Classroom discussions were lively. Most of the class time was spent on essentials, although outside topics, anecdotes and examples did manage to work themselves in with appropriate frequency. Student interest seemed to remain at a high level throughout the course and was student and objective-statement stimulated rather than instructor stimulated.
7. A small amount of data regarding student performance in the next course (Chemistry 101 at TCC) indicated that Chemistry 100 learned through objectives and repeat testing was about equivalent to the same study involving the conventional lecture-discussion method (See Table I.)
8. It is interesting to note that in the Chemistry 100 classes which formed the basis of this study, students overwhelmingly preferred to buy the standard textbook rather than use copies of the many other excellent textbooks which were on reserve in the library. Having the same reading source for all students turned out to be more important to them than saving the ten dollar textbook cost.

## COMMENTS

I believe that it is very likely to be both useful and reasonable for any science instructor to develop and distribute detailed lists of his course objectives. Competent instructors are already using objectives, in at least oral form, so that for those who haven't done so already, writing them down and distributing them to students would be a somewhat time consuming but rather straightforward task. The usefulness of writing course objectives lies in the necessary review and organization which the instructor is forced to make in order to complete the task, and in the increased service to students which the written objectives provide. Objectives, incidentally, are not only helpful to students in the

classroom, but can also serve as excellent advising tools for prospective enrollees.

In addition to the benefits mentioned above, the use of adequately written instructional objectives and detailed supplementary material substantially helps the student who becomes ill during the course and thus misses several classes. Instead of having to ask for special help, back lecture notes, assignments and the like, this student can often use the carefully prepared classroom handouts to recoup the majority of the work he has missed. This typical lessening of the pressure on the classroom instructor should provide motivation to the instructor who wishes to improve his work and his life in general.

Many instructors have been antagonized by the hucksters of objectives to the point where resistance to them is very high. Experience has persuaded me, however, to believe that any instructor who earnestly tries to use objectives has an excellent chance to be both pleased and excited about having done so. The key to success, however, lies in the word "earnestly." An instructor whose attitude toward objectives is negative may well find that they do not help him do an effective job. He may even be able to "prove" that they are a hindrance. In my opinion, those who advocate that all instructors be <u>required</u> to use formal objectives overlook this point and are guilty of oversimplifying and attempting to stereotype the teaching-learning experience.

It must also be remembered in reading about my classes that I have been working in a field which is rich in factual information, precision measurements and definitions. Analogous work in the social sciences and humanities is warranted and would be extremely informative.

Finally, my work probably could be extended to completely eliminate the lecture system and structured class time for the introductory chemistry course. Such a development (individualized study) might well allow more students to earn credit in that course with little or no increase in instructional costs.

## DATA

To support many of the above statements, I have added the data in Tables II and III which were obtained via course evaluation forms (student responses).

TABLE I

GRADE DISTRIBUTION IN CHEMISTRY 101

WINTER 1972

| Grades | Students With Regular Chem 100 | Students With Chem 100 Via "Objectives" |
|---|---|---|
| A | 4 | 4 |
| B | 6 | 4 |
| C | 3 | 4 |
| D | 1 | 1 |
| E | | |
| W | | |

TABLE II

COURSE EVALUATIONS (BY STUDENTS) FOR CHEMISTRY 100 AT TACOMA COMMUNITY COLLEGE

| ategory | Fall 1970 Conventional Lecture-Discussion System<br>Average Response A=5, B=4, etc. | Fall 1971 Original Trial With Instructional Objectives<br>Average Response A=5, etc. | Winter 1972 Modified Objectives, Experiments & Grade Criteria<br>Average Response A=5, etc. | Change (Column 3 minus Column 1) |
|---|---|---|---|---|
| rganization | 4.00 | 4.13 | 4.56 | +.56 |
| earning Emphasis | 3.93 | 3.60 | 4.39 | +.46 |
| ams | 4.26 | 4.30 | 4.72 | +.46 |
| rading | 4.60 | 4.56 | 4.44 | -.16 |
| ssignments | 4.00 | 4.18 | 4.72 | +.72 |
| ab or Discussion | 4.20 | 3.39* | 4.39 | +.19 |
| ext | 3.60 | 3.42 | 3.94 | +.34 |
| eneral Rating of Course | 4.26 | 4.26 | 4.59 | +.33 |
| nstructor Interest | 4.42 | 4.65 | 4.61 | +.19 |
| resentation | 4.20 | 4.47 | 4.22 | +.02 |
| nstructor Preparation | 4.33 | 4.47 | 4.56 | +.23 |
| nstructor Attitude Toward Students | 4.66 | 4.73 | 4.83 | +.17 |
| nstructor Mannerisms | 4.66 | 4.69 | 4.72 | +.06 |
| eneral Rating of Instructor | 4.40 | 4.65 | 4.78 | +.38 |

*A large amount of student criticism of laboratory instructional materials.

TABLE III

Responses to Student Attitude Form Which Focused on the Use of Instructional Objectives

| Question | Fall '70 Lecture-Discussion Style -- No Data | Fall '71 Original Trial With Instructional Objectives | Winter '72 Second Trial With Instructional Objectives |
|---|---|---|---|
| 1. At the beginning of this course you were informed that you need not buy a textbook because various texts were on reserve in the library. | | | |
| a. Did you buy a text anyway? | ---------- | 23 yes 3 no | 19 yes 2 no |
| b. Did you use any of the texts on reserve in the library? | ---------- | 10 yes 15 no | 12 yes 7 no |
| c. Would you advise future students to buy the textbook? | ---------- | 26 yes 0 no | 20 yes 1 no |
| 2. Each week or so you received a statement of your instructional objectives for the current study topic. | | | |
| a. Was the distribution of such objectives a good idea? | ---------- | (1) an excellent idea 20<br>(2) a good idea 5<br>(3) a fair idea 0<br>(4) a poor idea 0<br>(5) a bad idea 0 | (1) an excellent idea 18<br>(2) a good idea 3<br>(3) a fair idea 0<br>(4) a poor idea 0<br>(5) a bad idea 0 |
| b. Were the objective statements clear? | ---------- | (1) completely clear 9<br>(2) clearer than average 8<br>(3) about average 7<br>(4) not very clear 1<br>(5) not clear at all 0 | (1) completely clear 7<br>(2) clearer than average 12<br>(3) about average 2<br>(4) not very clear 0<br>(5) not clear at all 0 |
| c. Did the objectives make it easy to study the textbook? | --- | (1) extremely easy 13<br>(2) fairly easy 8<br>(3) about average 4<br>(4) not very easy 0<br>(5) did not help at all 0 | (1) extremely easy 10<br>(2) fairly easy 9<br>(3) about average 2<br>(4) not very easy 0<br>(5) did not help at all 0 |

TABLE III (continued)

Responses to Student Attitude Form Which Focused on the Use of Instructional Objectives

| QUESTION | Fall '70 Lecture-Discussion Style -- No Data | Fall '71 Original Trial With Instructional Objectives | Winter '72 Second Trial With Instructional Objectives |
|---|---|---|---|
| 3. At the start of the course you were informed of the requirements for course grades (A,B, C, etc.) a. Do you believe that knowing the grade requirements in advance was helpful? | ---------- | (1) very helpful 21<br>(2) moderately helpful 3<br>(3) average 2<br>(4) not very helpful 0<br>(5) of no use at all 0 | (1) very helpful 14<br>(2) moderately helpful 5<br>(3) average 2<br>(4) not very helpful 0<br>(5) of no use at all 0 |
| b. Were the grade requirements reasonable? | ---------- | (1) extremely reasonable 18<br>(2) fairly reasonable 7<br>(3) average 1<br>(4) not very helpful 0<br>(5) completely unreasonable 0 | (1) extremely reasonable 13<br>(2) fairly reasonable 7<br>(3) average 1<br>(4) not very helpful 0<br>(5) completely unreasonable 0 |
| 4. In each study unit you have taken tests until you could achieve a passing score. a. Do you believe that being able to repeat the test helped you to learn the required material? | ---------- | (1) very helpful 20<br>(2) moderately helpful 4<br>(3) average 2<br>(4) not very helpful 0<br>(5) no help at all 0 | (1) very helpful 19<br>(2) moderately helpful 1<br>(3) average 1<br>(4) not very helpful 0<br>(5) no help at all 0 |
| 5. How do you rate the learning emphasis in this class? | --- | (1) excellent 9<br>(2) better than in most classes 12<br>(3) about average 4<br>(4) poorer than in most classes 1<br>(5) very bad 0 | (1) excellent 12<br>(2) better than in most classes 9<br>(3) about average 0<br>(4) poorer than in most classes 1<br>(5) very bad 0 |

TABLE III (continued)

Responses to Student Attitude Form Which Focused on the Use of Instructional Objectives

| | Fall '71 | Winter '72 |
|---|---|---|
| 6. Given a choice, would you prefer a class which involved the special techniques used in Chem. 100 (specified objectives, repeat tests, optional text), or would you prefer one which is taught in another manner? | | |
| a. Chemistry 100 style | a. 21 | a. 20 |
| b. Another manner | b. 2 | b. 0 |
| 7. Do you believe it has been easier to learn in this class than it would have been if the class had been taught in a more conventional manner? | a. Yes 19<br>b. No 1<br>c. Don't know 5 | a. Yes 20<br>b. No 1<br>c. Don't Know 0 |
| 8. Do you believe you have learned more in this class because of the special techniques used? | a. Yes 18<br>b. No 2<br>c. Don't know 6 | a. Yes 20<br>b. No 0<br>c. Don't know 1 |
| 9. Do you believe you have learned more efficiently in this class because of the special techniques used? | a. Yes 20<br>b. No 3<br>c. Don't know 3 | a. Yes 20<br>b. No 0<br>c. Don't know 1 |

## APPENDIX A

### STUDENT OBJECTIVES[1] FOR CHEMISTRY 100

Study Topic: Periodic Arrangement of the Elements

6-1. To describe the meaning of the expression "periodic law of the elements" in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-2. To state the fundamental basis for the arrangement of the periodic chart in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-3. To state the definition of a "period" of elements in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-4. To state the definition of a "family" of elements in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-5. To describe the general atomic size relationship which is encountered as one moves from left to right across the 2nd period of elements, in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-6. To describe the general atomic size relationship which is encountered as one moves from the top to the bottom of a family of elements, in class by 11/5/71 at a test* time of 4 to 2 minutes.

6-7. To state the general locations of the most active metallic and non-metallic elements on the periodic chart, in class by 11/5/71 at a test* time of 2 to 1 minutes.

6-8. To state the meaning of a "group" of elements in class by 11/5/71 at a test* time of 4 to 2 minutes.

*Test Conditions: The student will bring a pen or pencil and will be given a test paper which has work space on it. The student is not to bring reference materials, notes or blank paper.

[1]van Ostrom system

## APPENDIX B

### STUDENT OBJECTIVES[1] FOR CHEMISTRY 100

Study Topic: Periodic Arrangement of the Elements

In class, under test conditions*, be able to:

6-1. Describe the meaning of the expression "periodic law of the elements."

6-2. Identify the subatomic particle which is primarily responsible for the shape of the periodic table.

6-3. State the definition of a "period" of elements.

6-4. State the definition of a "family" of elements.

6-5. Diagram the atomic size relationship which is encountered as one moves from left to right across the 2nd period of elements.

6-6. Describe the general atomic size relationship which is encountered as one moves from the top to the bottom of a family of elements.

6-7. State the general locations of the strong (most active) metallic and strong (most active) non-metallic elements on the periodic chart.

6-8. State the meaning of a "group" of elements.

*Test Conditions: The student will bring a pen or pencil and will be given a test paper which has work space on it. The student is not to bring reference materials, notes or blank paper.

[1]simplified version

## APPENDIX C

### COURSE CONTENT - CHEMISTRY 100

Major Topics

1. Introduction to chemistry
2. Standards for measurement
3. Properties of matter
4. Elements and compounds
5. Atomic theory and structure
6. Periodic arrangement of the elements
7. The formation of compounds from atoms
8. Nomenclature of inorganic compounds
9. The quantitative composition of compounds
10. Chemical equations
11. The gaseous state of matter

Minor Topics

Solutions

Ionization: acids, bases and salts

Oxidation and reduction

Radioactivity

Carbon and its compounds

## APPENDIX D

### MEMORANDUM TO STUDENTS

Subject: (1) Course Objectives, (2) Grading Criteria, (3) Course Evaluation System, and (4) Textbook Requirement.

In order to provide you with the maximum opportunity for efficiency as you study and gain insight into the field of chemistry, this section of Chemistry 100 will be taught using specific instructional objectives. In other words, you will be provided with firm statements of the requirements of the course and of the methods by which your learning performance will be tested and graded.

LEARNING

Your learning performances in this class have been designed to be as follows:

1. To perform 7 to 9 laboratory experiments, according to the instructions which will be provided once each week, by 12/10/71, at a classroom time of 2-1 hours per week.

2. To read two non-textbooks of your own choice from the chemistry or physics sections of the TCC Resource Center, or the equivalent (such as the Tacoma Public Library) by 12/10/71 at a total reading time of 8-4 hours.

3. To write and hand in book reports (one or two pages each) on the two non-textbooks which you have selected and read for this course, by 12/10/71 at a total writing time of 4 to 2 hours.

4. To keep a looseleaf notebook of your study notes for this course, and to turn in your notebook for review by the instructor each Monday during the quarter.

5. To take twenty minute tests covering the course objectives until a score of 80 to 100 per cent is reached in at least six study areas.

6. To take twenty minute tests covering all of the course objectives until a score of 80 to 100 per cent is reached in all study areas.

7. To score 80 to 100 per cent on a final review test covering all of the course objectives, during the week of 12/13/71 at a test time of 2-1 hours.

TESTING

Normally, the twenty minute tests will be given during each classroom session. The first test or "pre-test" for each study unit will usually be given before the material is discussed in class. The pre-test is meant to measure your prior knowledge of the material which is being studied. You will probably achieve low scores on most of the pre-tests. From them, however, you should be able to determine the parts of the unit which will require further study, and the parts where your knowledge is already satisfactory.

APPENDIX D (Continued)

All of the tests on each study unit will be quite similar to the pre-test. Your scores should improve with each test. Classroom discussions will be held after each test to help clarify the study units. When you are able to score at least 80 per cent on a test, you will have satisfactorily completed the study unit. It is important for you to realize that you may be tempted to memorize test answers without understanding why the answers are true. You must discipline yourself, however, to strive for understanding. Understanding basic material will make it possible for you to learn more advanced concepts later in your college or business career. When you do not understand a point, ask for help. Your instructor will be available in the classroom to help you, and he will also help you at his office in Building 14.

GRADING

If you are able to fulfill all of the learning objectives outlined above by 12/13/71, you will receive an "A" grade in this course. "B" grades will be awarded to students achieving all but one of the learning objectives stated above and "C" grades will be awarded where all but two of the objectives have been met. Attendance throughout the course will be the minimum requirement for a "D" grade. All other students will be awarded a "W."

COURSE EVALUATION

At the conclusion of this course, students will be asked to help evaluate the learning and teaching procedures used. The TCC Course Evaluation Form will be distributed and students may use it to praise or criticize any aspect of the course. A summary of the results will be given to the instructor and another will be filed in the Dean's office.

TEXTBOOK

There is no required textbook for this section. Students who wish to buy the text-book which is normally used in Chemistry 100 at TCC may purchase a copy of Hein: Foundations of College Chemistry, Second Edition at the TCC Bookstore.

Since the learning objectives for this course are specified rather precisely, however, it should be possible for you to use any one of the many available introductory textbooks. Several of them, which may be borrowed from the library, are listed on the attached sheet. If you plan to use a library book, try to select one which is easy for you to read and understand. Also, please be considerate of your fellow students by returning any borrowed books as soon as you have finished the current study unit. You may have selected the best textbook for a particular topic, so why not let others benefit from it too?